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Development of Early Maturing Varieties in Groundnut (*Arachis hypogaea* L.)

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ABSTRACT

Background: In view of developing early maturing groundnut that fit in high intensity multiple cropping system the present study was taken up to introgress early maturing traits in the well-established high yielding varieties.

Methods: VRI 8, CO 7, ICGV 07222 and VRI 6 were takenas the variety to be improved and as a source for early maturity and male parent in the study *viz.,* VRI 3, Chico, ICGV 91114 and ICGV 93468 were used. A crossing program was designed using these parent materials and selected crosses were forwarded to the next F_2 generation and their backcross populations were also generated. The data recorded were subjected to Generation mean analysis and association analysis.

Result: With consideration of early maturity and high pod yield the genotypes F_2 of CO 7 × Chico and ICGV 07222 × Chico and B_2 of ICGV 07222 × Chico recorded high mean values for the traits. The presence of duplicate epistasis was observed for, days to accumulation of 25 flowers (DTF) and days to maturity. This indicates that, inter-mating the selected segregating generations could result in the accumulation of favourable genes. The trait pod yield per plant exhibited positively significant correlation with days to accumulation of 25 flowers, days to maturity in all the crosses and the trait days to accumulation of 25 flowers is positively correlated to days to maturity. Thus, the trait - days to accumulation of 25 flowers is the major selection factor for early maturity in groundnut.

Key words: DTF, Days to maturity, Duplicate epistasis, Early maturity, Inter-mating.

INTRODUCTION

Oilseed crops are an important determinant of agricultural economy, next to cereals within the segment of field crops. Groundnut (*Arachis hypogaea* L.) is the 3rd most important oil seed crop of the world cultivated in about 108 countries of world (Upadhyaya *et al*. 2003).

Among the major groundnut producing states of India, Gujarat stands first place in area and production of groundnut followed by Andhra Pradesh while yield per hectare (productivity) was high in Tamil Nadu followed by Rajasthan.

One of the solutions to increase yield and economic benefits is development of high yielding progenies with short crop duration or early-maturing trait. The highly indeterminate fruiting pattern of groundnut and the fact that the pods grow underground, make the prediction of groundnut maturity a difficult task with potentially large economicconsequences if an incorrect decision is made (Pattee *et al.* 1974). Considering all this itis experienced by the groundnut cultivators that the varieties with optimum maturingduration of nearly 100 days are profitable and also flexible in crop rotation.

As reported by Nigam (2014), while breeding for early maturity in groundnut, for the botanical characteristics and physiological behaviour of the crop, the following characteristics could be visualized: Short plant stature with shorter inter-nodal length, faster germination and emergence, fewer days to first flowering, and accumulation of a maximum number of early flowers and high shelling turnover. Such characters could be seen in the species *Arachis hypogaea* Subspecies *fastigiata* with botanical varieties *fastigiata* (Valencia type) and *vulgaris* (Spanish type) that have terminating flowering habits which is most suitable for the development of short duration progenies (Shokes and Melouk, 1995).

Upadhyaya and Nigam (1994) have reported that three independent genes with complete dominance governed the days to accumulation of 25 flowers while days to first flowering was governed by additive gene action of a single gene. In the cross between early and late maturing genotypes the segregation pattern of days to maturity was observed to be dominant-recessive epistasis. Hence, it provides a better opportunity to improve the complex trait of early maturity in groundnut through recombination breeding.

Thus, taking this research as a base, the present study was taken up to understand the complexity of maturity in groundnut and develop genetic stocks with a potential of early maturing and high yielding groundnut varieties.

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MATERIALS AND METHODS

In the present study, the established high yielding varieties with maturity duration more than 100 days VRI 8, CO 7, ICGV 07222 and VRI 6 were selected as female parents and early maturing source varieties VRI 3, Chico, ICGV 91114 and ICGV 93468 were selected as male parents. The parental variety details are furnished in the Table 1. Theses selected plants were crossed in l × t fashion.

The crosses were evaluated during *kharif*, 2019 and among the parental combinations the crosses VRI 8 × VRI 3 (C_1), CO 7 × Chico (C_2), ICGV 07222 × Chico (C_3), ICGV 07222 × ICGV 91114 (C_4) and VRI 6 × ICGV 93468 (C_5) with fair heterosis and promising mean performances for early maturity, pod and kernel yield per plant were further advanced to assess the nature of gene action by generation mean analysis by generating the backcross population to both the parents (B_1 and B_2) and F_2 population. The six generations of the selected crosses *viz*., P_1, P_2, F_1, F_2, B_1 and B_2 were sown in randomized block design with two replications during *rabi*, 2020, at the Department of Oilseeds, Tamil Nadu Agricultural University. The number of plants studied per replication in each of the population in each cross is tabulated in the Table 2. The two main component characters to develop early maturity groundnut varieties are days to accumulation of 25 flowers and days to maturity were recorded for these plants.

The data for the six generations of the selected crosses *viz*., P_1, P_2, F_1, F_2, B_1 and B_2 were subjected to six parameter model of generation mean analysis using Mather and Jinks (1982) method followed by association analysis for the early maturing traits towards yield using the method suggested by Johnson *et al.* (1955).

The resultant genetic stocks selected for the objectives were also scored for late leaf spot and rust using validated SSR markers (GM1573, GM1009, seq 8D09, GM2009, GM1536 and IPAHM103) to suggest valid breeding programmes for further improvement.

RESULTS AND DISCUSSION

For both the traits under study the joint scale test, exhibited significance for either of the two scales A and B of C and D in all the crosses indicating the presence of non-allelic interactions. Further, the gene action for the two traits is furnished hereunder.

Days to accumulation of 25 flowers

The second backcross generations (B_2) of the crosses CO 7 × Chico recorded the lowest days to accumulation of 25 flowers in comparison to all the generations of the other crosses except to that of the male parents. The F_1s of the crosses CO 7 × Chico and ICGV 07222 × Chico recorded significant lower days for DTF (Table 3).

All the crosses recorded significant positive dominant (h) gene action for the trait days to accumulation of 25 flowers. In addition to this all the crosses recorded various other interactions that are described hereunder.

The crosses VRI 8 × VRI 3, CO 7 × Chico, ICGV 07222 × ICGV 91114 and VRI 6 × ICGV 93468 recorded dominant (h) and dominant × dominant (l) effects in opposite direction suggesting duplicate epistasis. The crosses ICGV 07222 × Chico, ICGV 07222 × ICGV 91114 and VRI 6 × ICGV 93468 recorded significant additive × additive (i) interaction (Table 4 and 5). Thus, the trait displays duplicate dominant epistasis with additive effect resulting in reduced heterosis and selection for the trait would surely lead to fruitful genetic gain. These results are in confirmation with that reported by Gadakh *et al,* (2019) for days to 50% flowering in groundnut. They have recorded dominant epistasis with additive,

Table 1: Details of parents used in the program.

Genotype	Duration (days)	Pedigree	Source	Habit
CO7	105-110	ICGV 87290 × ICGV 87846	TNAU, Coimbatore	Spanish Bunch
ICGV07222	95-122	[(ICGV 92069 × ICGV 93184) SIL 4 × (ICGS 44 × ICGS 76)]	ICRISAT, Hyderabad	Spanish Bunch
VRI 6	120-125	ALR 2 × VG 9513	RRS, Vridhachalam	Spanish Bunch
VRI 8	105-110	ALR 3/ AK 303	RRS, Vridhachalam	Spanish Bunch
VRI 3	90	J11 × R 33-1	RRS, Vridhachalam	Spanish Bunch
Chico	75	Registered in USA	Received from ICRISAT	Spanish Bunch
ICGV91114	90-95	ICGV 86055 × ICGV 86533 cross	ICRISAT, Hyderabad	Spanish Bunch
ICGV93468	85-90	Avtar in Uttar Pradesh	ICRISAT, Hyderabad	Spanish Bunch

Table 2: The number of plants recorded for the generation mean population in each cross.

Cross no.	Cross	P_1	P_2	F_1	F_2	B_1	B_2
C_1	VRI 8 × VRI 3	25	25	10	200	25	25
C_2	CO 7 × Chico	25	25	10	200	25	25
C_3	ICGV 07222 × Chico	25	25	10	200	25	25
C_4	ICGV 07222 × ICGV 91114	25	25	10	200	25	25
C_5	VRI 6 × ICGV 93468	25	25	10	200	25	25

Table 3: Estimates of generation means and standard errors for days to accumulation of 25 flowers .

Cross no.	Cross	P_1	P_2	F_1	F_2	B_1	B_2
C_1	VRI 8 × VRI 3	15.32±0.26	10.32±0.26	13.90±0.31	14.22±0.30	14.84±0.35	13.04±0.23
C_2	CO 7 × Chico	14.16±0.23	6.40±0.24	12.80±0.70	13.02±0.39	14.08±0.40	12.88±0.34
C_3	ICGV 07222 × Chico	16.00±0.24	6.72±0.29	13.03±0.31	14.02±0.35	15.52±0.28	14.84±0.42
C_4	ICGV 07222 × ICGV 91114	16.32±0.23	7.04±0.21	14.80±0.29	14.46±0.29	15.36±0.24	14.28±0.26
C_5	VRI 6 × ICGV 93468	17.96±0.21	8.04±0.25	13.4±0.58	15.64±0.30	14.76±0.24	16.76±0.26

Table 4: Joint scale test for days to accumulation of 25 flowers.

Cross no.	Cross	A	B	C	D	m	d	h	χ^2
C_1	VRI 8 × VRI 3	13.18**	2..86*	11.44**	-0.44	13.95**	-6.66	-2.50	14.51**
C_2	CO 7 × Chico	4.20*	0.56	5.16*	2.20*	12.82**	0.71	4.36*	17.05**
C_3	ICGV 07222 × Chico	-10.06**	-5.14*	1.16	4.68*	14.37**	0.76	3.63*	10.69*
C_4	ICGV 07222 × ICGV 91114	1.60**	1.72**	1.88	-0.72	13.36**	0.06	3.16*	11.07*
C_5	VRI 6 × ICGV 93468	0.16	0.08	5.76**	2.76**	14.05**	-1.03	2.95*	17.28**

Table 5: Estimates of gene effects based on six parameter model for days to accumulation of 25 flowers.

Cross no.	Cross	m	d	h	i	j	l	Epistasis
C_1	VRI 8 × VRI 3	13.22**	-1.04	2.80**	0.88	0.30	-3.20**	D
C_2	CO 7 × Chico	12.08**	-4.38	4.20**	3.64	-0.18	-4.40**	D
C_3	ICGV 07222 × Chico	14.02**	-0.62	3.68**	4.36**	0.04	1.56	-
C_4	ICGV 07222 × ICGV 91114	13.46**	1.06	3.08**	5.44**	-0.06	-4.76*	D
C_5	VRI 6 × ICGV 93468	14.64**	-1.12	3.00**	5.52**	0.04	-5.28*	D

*,** Significant at 5% and 1% level of probability.

Table 6: Estimates of generation means and standard errors for days to maturity.

Cross no.	Cross	P_1	P_2	F_1	F_2	B_1	B_2
C_1	VRI 8 × VRI 3	107.24±0.57	92.52±0.34	105.90±0.53	106.12±0.71	107.12±0.43	106.64±0.47
C_2	CO 7 × Chico	108.84±0.51	80.56±0.33	102.50±0.65	101.54±0.98	108.96±0.64	102.00±0.82
C_3	ICGV 07222 × Chico	117.88±0.46	81.08±0.61	105.40±8.65	103.14±1.09	109.6±0.51	103.06±0.58
C_4	ICGV 07222 × ICGV 91114	117.08±0.53	90.56±0.51	110.50±0.48	106.74±1.33	109.24±0.60	108.96±0.54
C_5	VRI 6 × ICGV 93468	114.64±0.77	90.04±0.43	110.3±0.70	107.88±0.95	109.08±0.68	109.48±0.90

Table 7: Joint scale test for days to maturity.

Cross no.	Cross	A	B	C	D	m	d	h	χ^2
C_1	VRI 8 × VRI 3	1.10	14.86**	4.92	-5.52**	100.29**	-6.37	8.42**	177.45**
C_2	CO 7 × Chico	6.58**	20.94**	11.76**	-7.88**	95.28**	-14.01	10.74**	143.96**
C_3	ICGV 07222 × Chico	-12.08	11.44	-12.40	-5.88*	100.08**	-16.13	14.67**	188.33**
C_4	ICGV 07222 × ICGV 91114	2.90**	16.86**	-1.68	-10.72**	105.13**	-11.98	7.66**	174.86**
C_5	VRI 6 × ICGV 93468	-2.78	4.62*	6.24	2.20	102.20**	-11.86	8.43**	12.06*

Table 8: Estimates of gene effects based on six parameter model for days to maturity.

Cross no.	Cross	m	d	h	i	j	l	Epistasis
C_1	VRI 8 × VRI 3	104.12**	0.48**	17.06**	11.04**	-6.88**	-27.00**	D
C_2	CO 7 × Chico	101.54**	6.96**	23.56**	15.76**	-7.18**	-43.28**	D
C_3	ICGV 07222 × Chico	105.34**	6.64**	29.68**	11.76*	-11.76**	-11.12	D
C_4	ICGV 07222 × ICGV 91114	106.74**	6.28**	28.12**	21.44**	-6.98**	-41.2**	D
C_5	VRI 6 × ICGV 93468	107.88**	8.60**	23.56**	14.40**	-3.70**	-22.56**	D

*,** Significant at 5% and 1% level of probability.

additive × additive and dominant × dominant effects. Also Upadhyaya and Nigam (1994) have reported duplicate dominant effects for days to accumulation of 25 flowers in groundnut. In genetic analysis of yield contributing traits in groundnut, Alam *et al.* (2013) have reported additive gene effects for days to 50% flowering. On awhole the trait days to accumulation of 25 flowers exhibits significant dominant effectsand duplicate epistasis suggesting that pedigree breeding would enable improvement.

Days to maturity

In the present study the parents are deliberately selected to generate segregating material with lower maturity duration in groundnut. The F_1s of all the crosses displayed intermediate values for days to maturity lower than the female parent show casing negative heterosis (Table 6).

The crosses recorded significant for additive (d), dominance (h), additive × additive (i), additive × dominant (j) and dominant × dominant gene interactions with h and l in opposite direction (Table 7 and 8). The result reveals the presence of duplicate epistasis. Similar results were reported by Halward and Wynne (1991) for days to maturity in groundnut.

In all the crosses the additive × dominant (j) effect was negatively significant while the magnitude of dominance (h) and additive × additive (i) were higher than that of additive (d). Thus, in all the crosses the presence of duplicate epistasis and significant additive, dominance and non-allelic interactions indicates that it is worthwhile to intermate the selected ones in segregating generations, which could result in the accumulation of favourable genes. Hence, biparental mating or few cycles of recurrent selection followed by pedigree method of selection may be followed for bringing improvement in this trait.

The B_1 generation of the cross ICGV 07222 × Chico (109.06 days) recorded 7.48% reduction in maturity duration than ICGV 07222 and high pod and kernel yield over CO 7. In the cross VRI 6 × ICGV 93468 the B1 (109.08 days) generation was early by 4.85% than VRI 6 and higher in pod yield than CO 7. The progeny B1 of ICGV 07222 × ICGV 91114 recorded higher pod, kernel and oil yield than CO 7 with a mean maturity duration of 109.24 days. This was a reduction of about 7.85% in maturity duration than that of ICGV 07222.

All these progenies exhibited moderate to resistant reaction to foliar diseases. Hence, forwarding of the genotypes could be done through pedigree breeding with simple selection. Scoring of these progenies for late leaf spot and rust resulted as the derivatives F_2 and B_2 of CO7 × Chico are susceptible to foliar diseases which could be subjected to pedigree and resistant breeding for advancement. The progenies B_1 of ICGV 07222 × Chico, VRI 6 × ICGV 93468 and ICGV 07222 × ICGV 91114 could be forwarded through selection. A quick comparison of the selected genotypes to standard check CO 7 is provided in the Table 9.

The trait pod yield per plant exhibited positively significant correlation with days to accumulation of 25 flowers, days to maturity in all the crosses (Table 10). Thus,

Table 9: Selected progenies and comparison with standard check CO 7 with recommendations.

Selected progenies	Mean DM (days)	% reduction WRT P_1	Mean PY/P (g)	% of PY/P over CO 7	Mean KY/P (g)	% of KY/P over CO 7	Oil content (%)	% of OC over CO 7	Reaction to LLS and R	Recommended breeding methodology
F_2 of CO 7 × Chico	101.54	6.70	29.59	97.40	17.84	102.88	46.8	96.09	Susceptible	Biparental mating followed by pedigree breeding and Resistant breeding
B_2 of CO 7 × Chico	102.00	6.29	29.85	98.25	16.92	97.75	45.2	92.81	Susceptible	Biparental mating followed by pedigree breeding and Resistant breeding
B_1 of ICGV 07222 × Chico	109.06	7.48	34.17	112.48	20.71	119.64	45.6	93.63	Moderately resistant	Selection could be practiced
B_1 of VRI 6 × ICGV 93468	109.08	4.85	33.06	108.82	16.91	97.69	46.3	95.07	Resistant	Selection could be practiced
B_1 of ICGV 07222 × ICGV 91114	109.24	7.85	30.94	101.84	19.52	112.78	49.2	101.03	Resistant	Selection could be practiced
CO 7			PY/P (g) 30.38				KY/P (g) 17.31	OC % 48.7		

DM - Days to maturity, WRT P_1 - With respect to female parent, PY/P - Pod yield per plant, KY/P - Kernel yield per plant, OC - Oil content, LLR - Late leaf spot, R - Rust.

Table 10: Simple correlation coefficients between pod yield and maturity traits.

	Days to accumulation of 25 flowers		Days to maturity		Kernel yield per plant		Pod yield per plant
Days to accumulation of 25 flowers	1.00						
Days to maturity	C_1	0.390*	1.00				
	C_2	0.605*					
	C_3	0.547*					
	C_4	0.515*					
	C_5	0.563*					
Kernel yield per plant	C_1	0.31*	C_1	0.163*	1.00		
	C_2	0.194*	C_2	0.381*			
	C_3	0.277*	C_3	0.174*			
	C_4	0.058	C_4	0.087			
	C_5	-0.047	C_5	0.036			
Pod yield per plant	C_1	0.380*	C_1	0.521*	C_1	0.563*	1.00
	C_2	0.247*	C_2	0.456*	C_2	0.517*	
	C_3	0.437*	C_3	0.338*	C_3	0.930*	
	C_4	0.197*	C_4	0.198*	C_4	0.857*	
	C_5	0.148*	C_5	0.196*	C_5	0.147	

*,** Significant at 5% and 1% level of probability, respectively (n=260).

C_1- VRI 8 × VRI 3, C_2- CO 7 × Chico, C_3- ICGV 07222 × Chico, C_4- ICGV 07222 × ICGV 91114, C_5- VRI 6 × ICGV 9346.

increase in these traits would result in increase of pod yield and are useful as selection criteria for the improvement of yield. It is evident from this study that the trait days to accumulation of 25 flowers is positively correlated to days to maturity which is also supported by the research works of Seshadri (1962) and Yadava *et al.* (1984). Hence, the trait - days to accumulation of 25 flowers is the major selection factor for early maturity in groundnut.

The study conducted with the aim of developing early maturing and high yielding progenies of groundnut with high oil content, a crossing program was steered involving genotypes of diverse origin. The developed derivatives from the study are F_2 and B_2 of CO 7 × Chico, B_1 of ICGV 07222 × Chico, ICGV 07222 × ICGV 91114 and VRI 6 × ICGV 93468 could be forwarded for further development of successful early maturing groundnut varieties. The study resulted in the assembly of genetic stocks having potential to develop successful groundnut varieties beneficial to the groundnut cultivating farmers of India.

Conflict of interest

All authors declared that there is no conflict of interest.

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